INTENSE RAINSTORM OF OCTOBER 4, 1919, AT DUBUQUE, IOWA.

On October 4 Dubuque was again visited, for the second time during 1919,[1] by a rainstorm of great intensity. The fall within an hour (2.66 inches) has been exceeded since the beginning of record 46 years ago only by the storm of July 9, 1919, and probably by the storm of July 4–5, 1876. The storm of October 4 gave a total of 3.38 inches, as compared to a total of 3.87 inches on July 9. Rainfall was not remarkable on either date for "total" amount, but for intensity of fall within an hour.

The great downpour occurred between 3.13 p. m. and 4.39 p. m., 90th meridian time, and was preceded by and followed by light rain. Rainfall was excessive from 3.18 p. m. until 4.38 p. m., and accumulated amounts during this period were as follows:

	Inches.		Inches.
5 minutes	0.15	35 minutes	2.18
10 minutes	.35	40 minutes	2.33
15 minutes	.70	45 minutes	2.44
20 minutes	1.27	50 minutes	2.54
25 minutes	1.63	60 minutes	2.66
30 minutes	1.98	80 minutes	2.97

The following table gives the greatest amount of rainfall in 5, 10, 15, 30, 45, 60, and 120 minutes during the storm of October 4, as compared with the storm of July 9, 1919:

Greatest amount in—	Storm of July 9.	Storm of Oct. 4.
	Inches.	*Inches.*
5 minutes	0.80	0.59
10 minutes	1.20	.96
15 minutes	1.52	1.35
30 minutes	2.23	2.06
45 minutes	2.64	2.43
1 hour	2.70	2.66
2 hours	3.03	3.06

The storm of October 4 was more local in character than that of July 9, and the area of heavy rainfall did not extend to Union Park, where great damage resulted on July 9. Intense rainfall, however, fell over the entire city, causing great damage to brick pavements on waterway streets. The effects of the storm within the city limits were practically a repetition of what occurred on July 9.

The brick surface of Eighth, a steep waterway street, was again ripped off for several blocks. Seventeenth and Twenty-second Streets experienced similar damage as on Eighth, though much less steep. Seventeenth was not much damaged on July 9. Kaufmann Avenue was in process of repaving due to damage from the storm of July 9, and much of the new work was ruined as before, causing heavy loss to the contractor. East of Clay and north of Sixteenth a flat, residential section two or more blocks wide and more than a mile long became a temporary lake during the storm and scores of cellars in this section were flooded and considerable property damaged.

There was other damage of a less serious nature in various parts of the city. The bathing beach property at Eagle Point, for instance, was much damaged for the third time this season. Losses outside the city were not heavy. Four small county bridges were damaged or destroyed by freshets, the loss amounting to about $3,000.

The total loss from this storm is estimated at about $60,000, at least two-thirds of which amount was to city streets. Fortunately, in this storm no lives were lost, as on July 9.—*J. H. Spencer.*

[1] See MONTHLY WEATHER REVIEW, July, 1919, 47; 468.

SOME BROADER ASPECTS OF RAIN INTENSITIES IN RELATION TO STORM-SEWER DESIGN.

By ROBERT E. HORTON.

[Abstracted from Municipal and County Engineering, June-July, 1919, 4°, 12 pp., 16 figs.]

Owing to the large number of rainfall intensity formulæ which are used in various localities in storm-sewer design, the author was led to make a study of them, with special relation to the underlying physical and meteorological causes of excessive rainfall. After defining the terms "rainfall rate" and "rainfall intensity" and pointing out the distinction of the two terms, namely, that "rate" implies quantity per unit of time, whereas "intensity" implies a quantity in a given time interval, the author explains the notation employed in formulæ and gives the several types into which these formulæ have fallen. The mechanism of the thunderstorm is then discussed, together with the character of the rainfall rates of different types of storms, tropical rainfall, and the frequency curves of excessive rains in New York. The following are some of the conclusions:

1. Excessive rain intensities for short-time intervals mostly occur in thunderstorms, or in storms of the thunderstorm type.
2. Rainstorms producing maximum intensities are mostly the result of violent convection.
3. The occurrence of thunder affords quite positive proof of the existence of suspension storage, and the sudden precipitation of such storage is probably a usual cause of high rain intensities for short intervals of 5, 10, or 20 minutes.
4. High rain intensities for longer intervals are probably due to storm gusts or pulses.
5. High rain intensities for long periods are result of general cyclonic conditions.

The writer has not attempted in this article to give definite formulæ of general applicability for the expression of the relation between rain intensity, duration, and frequency. It is hoped that the results given will suggest and encourage further study along similar lines, such as may afford a more complete basis for generalization.

The requirements for a rain intensity formula based on investigations thus far made may be stated as follows:

(1) It should indicate a finite intensity for zero duration and for the minimum exceedance frequency.

(2) For a given duration the rain intensity should approach a finite maximum or limiting value as the exceedance interval increases.

(3) The maximum or limiting value should decrease as the duration interval of the rain increases.

(4) A single general type of formula should be applicable ovel extensive geographic areas and to regions varying in amount of seasonar precipitation and thunderstorm frequency.

(5) The formula may contain constants whose values in turn can be expressed either in terms of unit rain intensity, thunderstorm frequency, or total precipitation during the thunderstorm season.

(6) The form of expression should be such as to give the required intensity in terms of duration and exceedance interval, so that when the constants are known for a given location intensities of varying duration, but of the same frequency, can be determined directly on the one hand, or intensities of the same duration, but of varying exceedance intervals, can be obtained directly on the other hand."

The paper affords an admirable example of one of the points where the engineering profession and the science of meteorology meet; indeed, where meteorology is indispensable.—*C. L. M.*